ETIP HYDROPOWER: impacts of climate change on water and energy security

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The energy transition process in Europe

The **geopolitical situation** and the **adaptation to climate change** demand for a **fast-changing European policy landscape**

- The **SET Plan** must adapt accordingly
- On October 2023, the EC released the **Communication** on the SET Plan's revision
- Crucial role in delivering the EU **Green Deal**, **REPowerEU** and the **Green Deal Industrial Plan**, which encompasses the **Net-Zero Industry Act** (NZIA) and the **Critical Raw Materials Act** (CRMA)

Who are the players of the SET Plan?

The **key actors** for the successful implementation of the SET-Plan in the 27 Member States are:

- the **Implementation Working Groups** (IWGs):
  - clusters of industrial and research stakeholders with the task of issuing Implementation Plans (IP) on specific energy technologies
- the **European Technology and Innovation Platforms** (ETIPs):
  - bring together EU countries, industries, and researchers in key areas to promote the market uptake of crucial energy technologies
- the **European Energy Research Alliance** (EERA):
  - Represents the research pillar of SET Plan

What about hydropower?

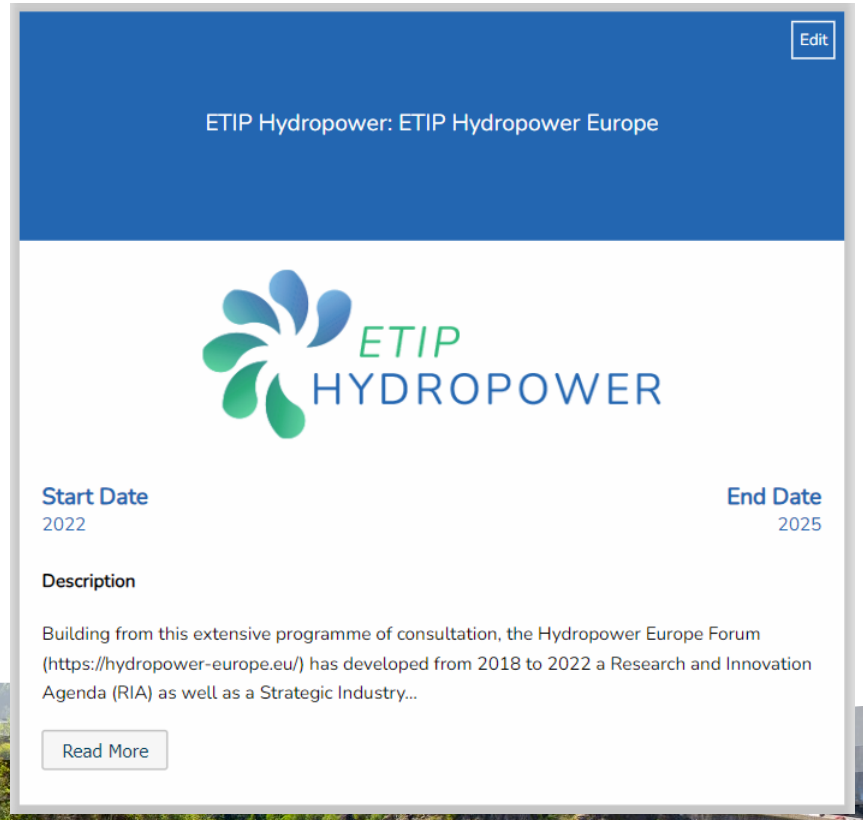
The **hydroelectric production** and the **ancillary services** that the hydropower plants can provide to the power network to underpin the exploitation of discontinuous renewable energy are **taken for granted**

The hydroelectric sector was defined a **mature technology** causing **a drastic reduction in funds for R&I**

Time to change paradigm to promote the hydropower sector as a crucial player in building the European Green Deal towards a climate-neutral energy system by 2050

The ETIP HYDROPOWER vision and mission

https://etip-hydropower.eu/



Unifying the voices of hydropower

- Identifying **priorities of R&I needs** considering the emerging policy strategies
- Building a **European Commission vision** on the role of hydropower in a future secure and clean energy system, and on its contribution to climate change adaptation
- Increasing the **flexibility** and **storage capacity** of hydropower plants with innovative solutions
- Making hydropower plants more **environmentally friendly** and **sustainable**

ETIP HYDROPOWER WGs

Focus on R&I priorities and strategic actions identified in the **Research and Innovation Agenda** (RIA) and in the **Strategic Industrial Roadmap** (SIR) issued by the Hydropower-Europe project

1. **Hydropower role for flexibility and storage**
2. **Hydropower and biodiversity**
3. **Hydropower and climate change (adaptation and mitigation)**

A. **Overview on past and current European R&I projects for hydropower**

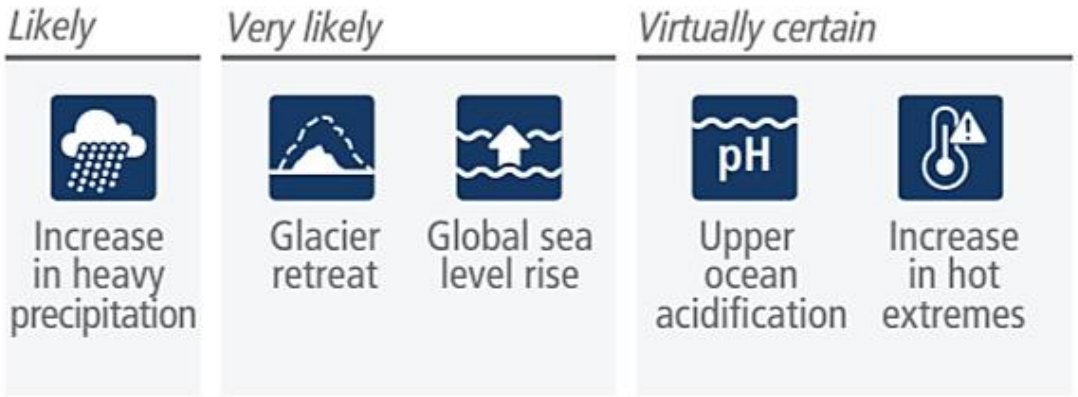
Join one or more WGs
secretariat@etip-hydropower.eu
email header: '**ETIP WG: …**'

Historical evolution of global temperature change

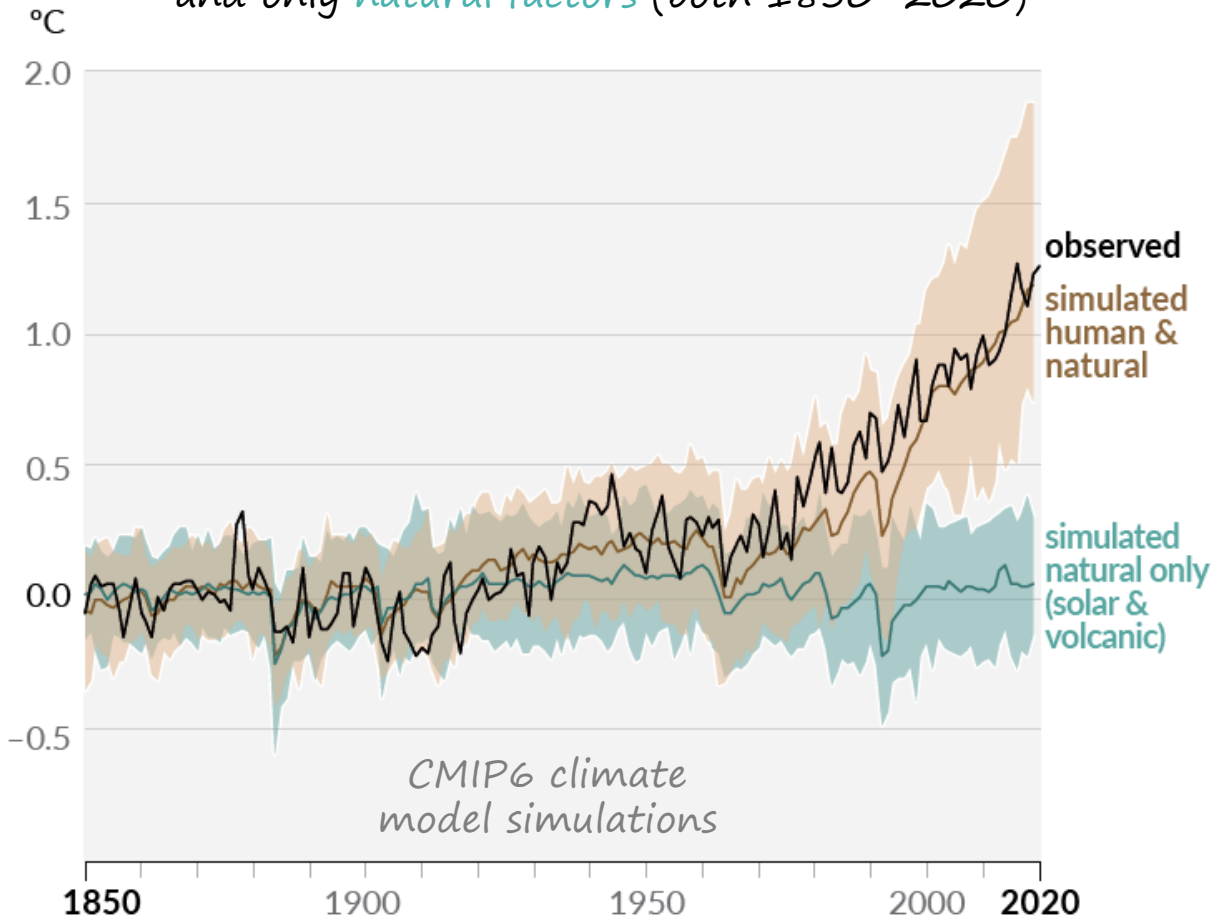
Current dynamics of global warming matches to the most severe past IPCC projections.

Global warming is accelerating

Human-caused climate change is already affecting many weather and climate extremes in every region across the globe.



Changes in global surface temperature (annual average) relative to 1850–1900 as **observed** and simulated using human & natural and only natural factors (both 1850–2020)



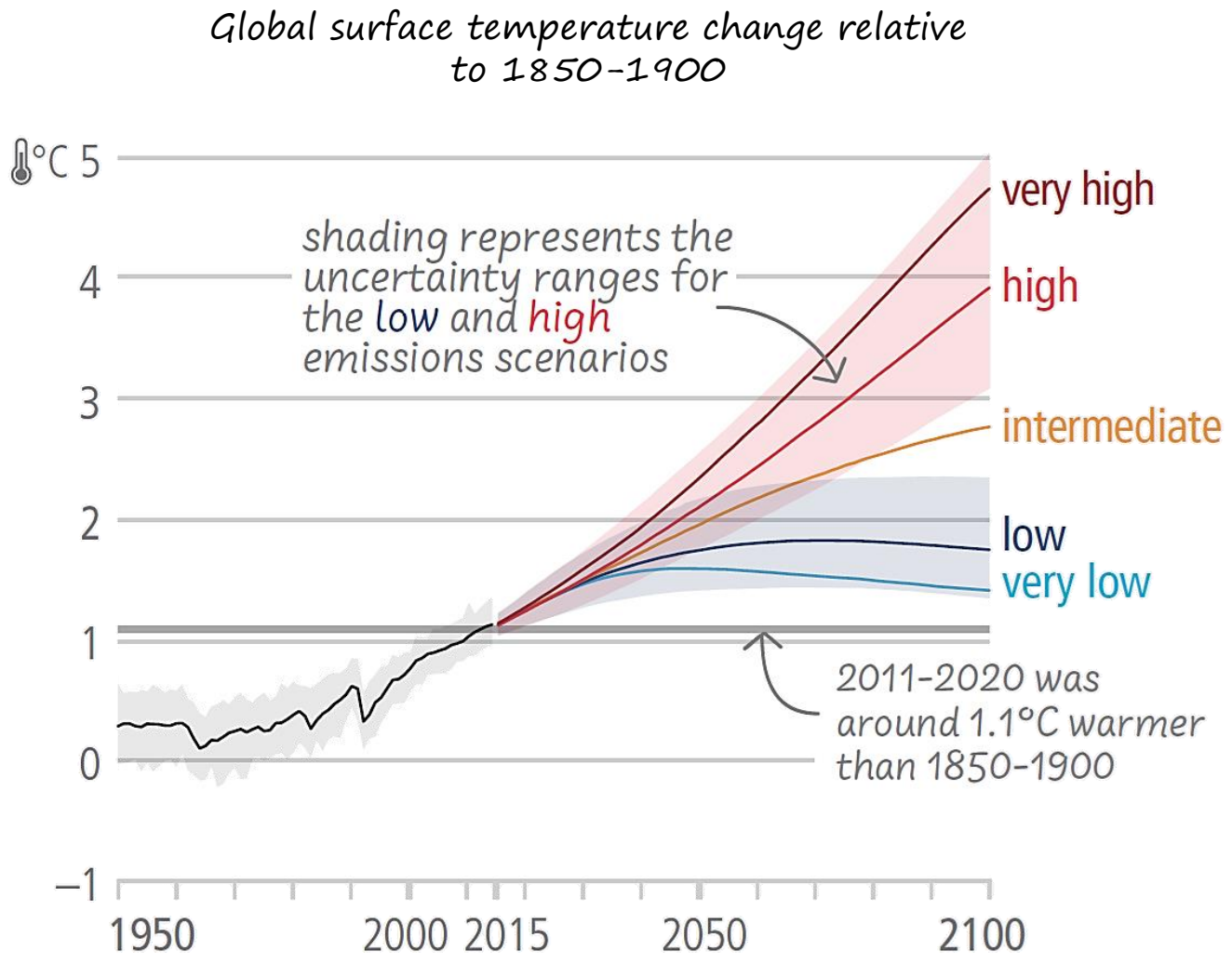
Source: IPCC AR6 - Climate Change 2021: The Physical Science Basis

Climate change: long-term projections

Future climate change is projected to **increase the severity of impacts** and will increase **regional differences**.

In the worst climatic scenarios, Europe will face several criticalities, hindering the efforts to meet Sustainable Development Goals:

- Risks to people, economies and infrastructures due to **coastal and inland flooding**.
- Stress and mortality to people due to **increasing temperatures and heat extremes**.
- Marine and terrestrial **ecosystems disruptions** and **hydrological changes**, namely in high-elevation area from glacier loss and shrinking snow cover.
- **Water scarcity** to multiple interconnected sectors, and risk to **water security** mostly in small islands.
- Reduced **food security**, due to compound heat and dry conditions, and extreme weather.



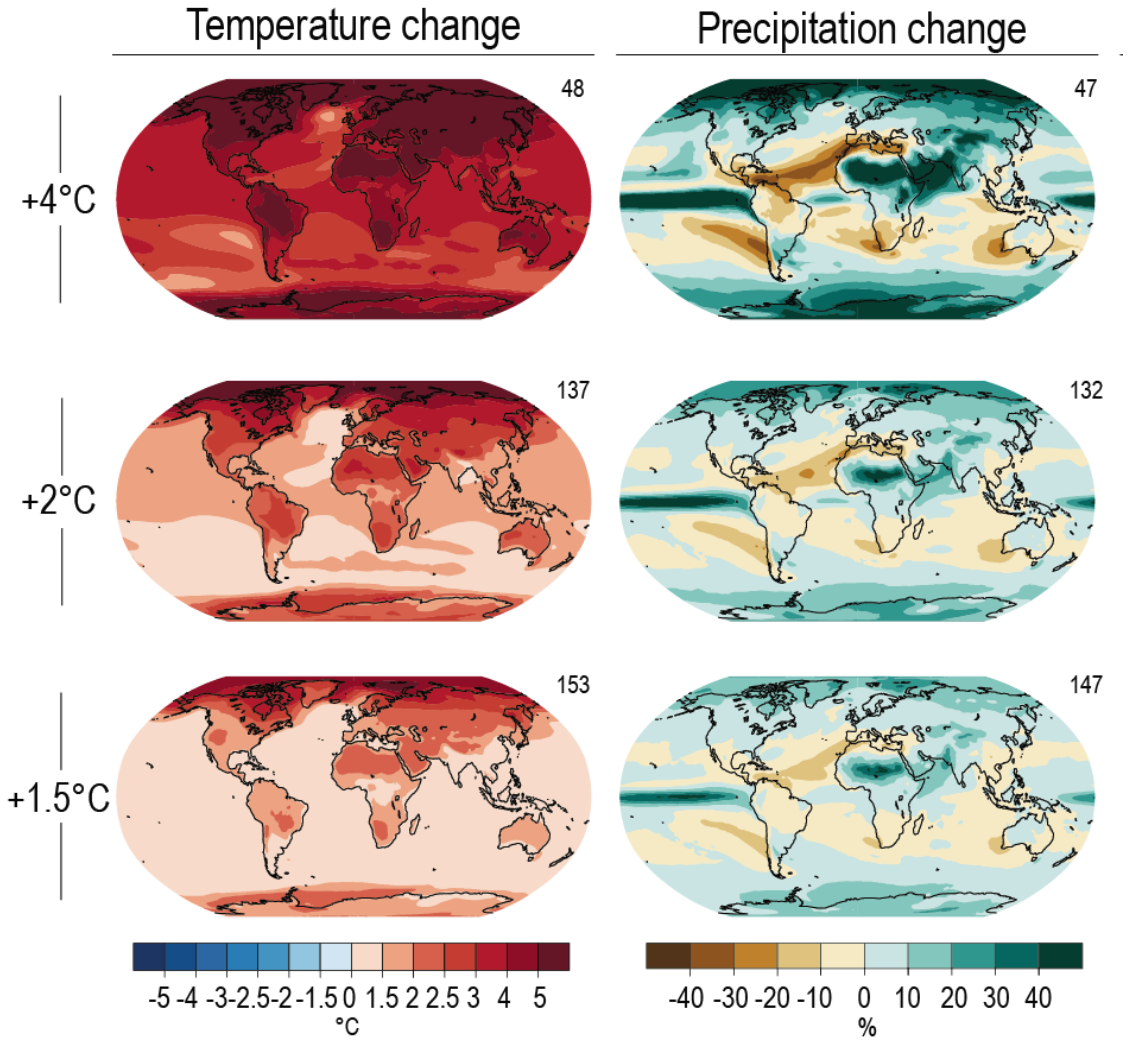
Source: IPCC AR6 - Climate Change 2023: Synthesis Report

Climate change: long-term projections

Climate change will manifest very differently depending on which region, season and variable we are looking at:

- Across warming levels, land areas warm more than ocean areas, and the Arctic and Antarctica warm more than the tropics.
- Precipitations will increase in high latitudes, the tropics and monsoon regions but drying is expected over the subtropics, particularly in the Mediterranean Areas.

Floods and **droughts** are currently among the most devastating water-related disasters



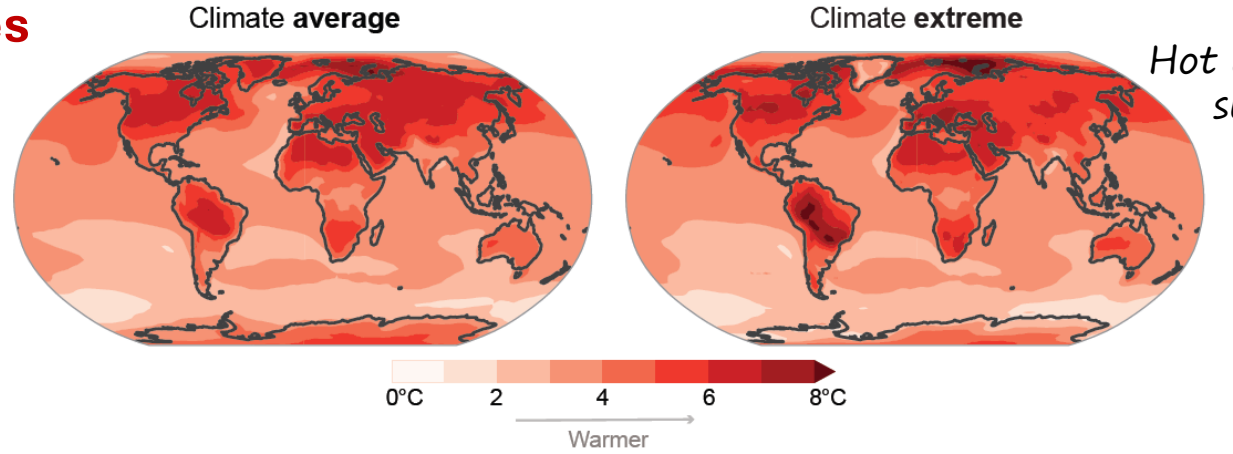
Source: IPCC AR6 - Climate Change 2021: The Physical Science Basis

Climate averages compared to climate extremes

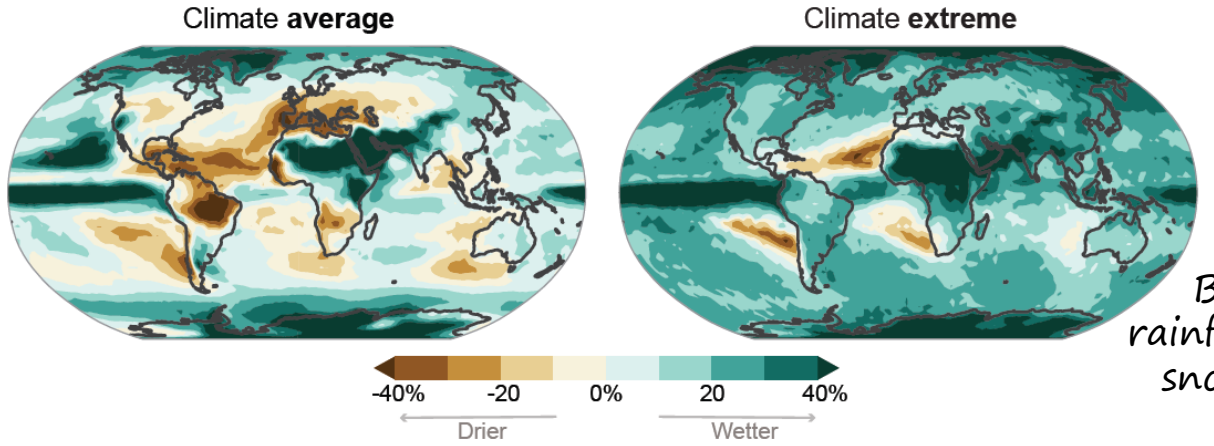
Changes in local **surface temperature extremes** **closely follow the corresponding changes** in local **average surface temperatures**.
The average and extreme values are shifted towards higher temperatures, making **warm extremes more frequent** than cold ones.

Changes in **precipitation extremes** (heavy precipitation) **generally do not follow those in average precipitation** and can even move in the opposite direction.
Precipitation changes may either compensate or exacerbate warming effects on flow regimes.

Scenario with a global warming of 4°C relative to 1850–1900 temperatures



Hot days in summer season



Both rainfall and snowfall

Source: IPCC AR6 - Climate Change 2021: The Physical Science Basis

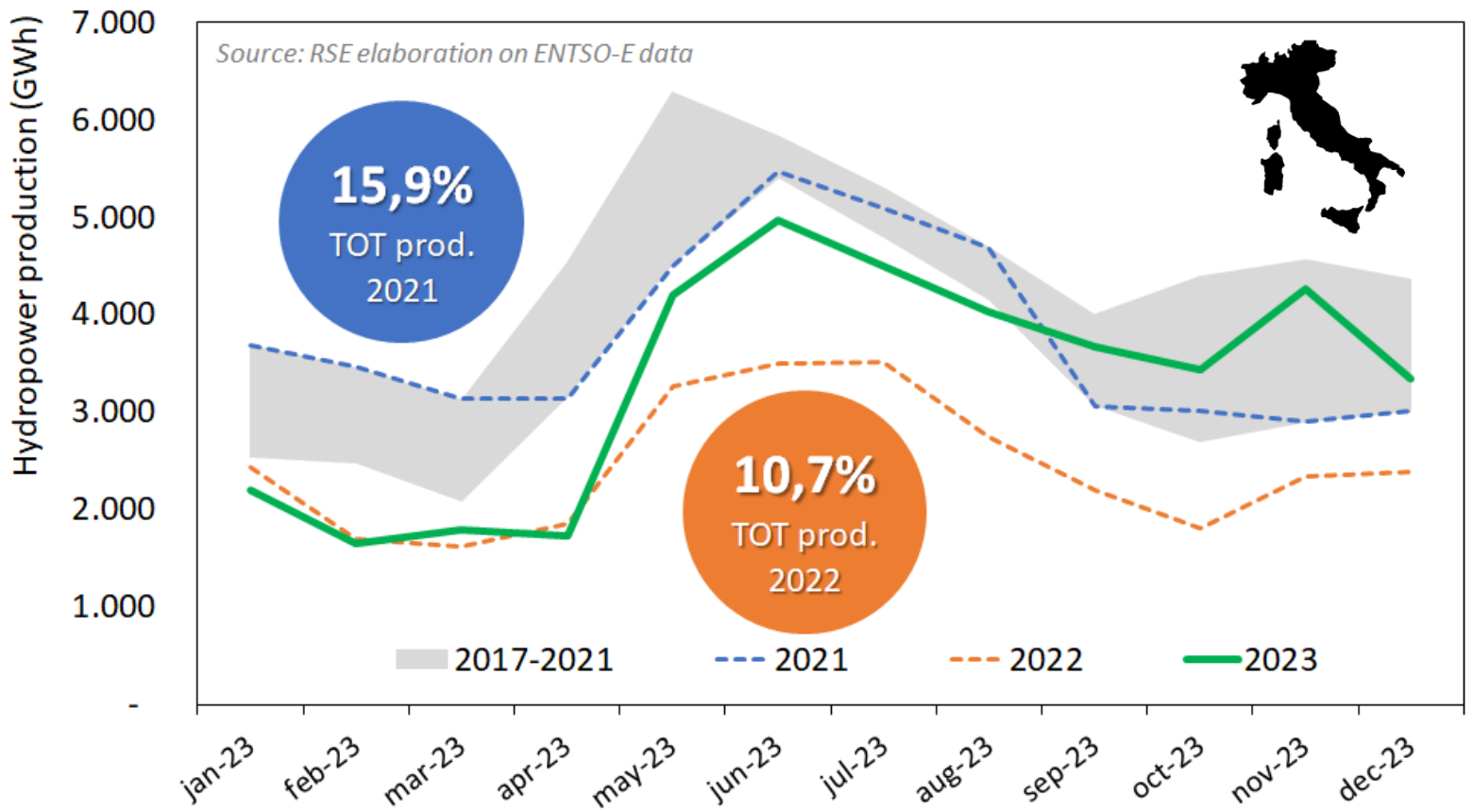
Impact on today's hydropower production

Worldwide the meteorological conditions directly affect the production of all types of hydropower plants.

In Italy, for instance, hydropower production fell to an all-time low in the **water crisis of 2022**, which affected many countries in southern Europe.

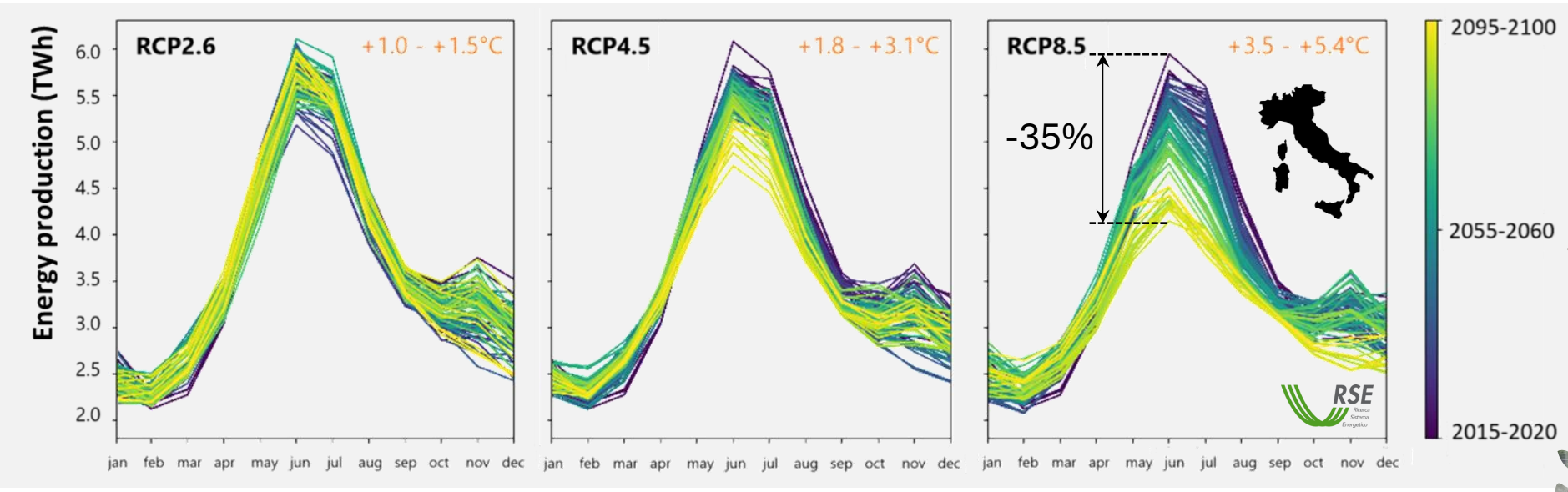
In 2023, the alert was reentered due to **heavy spring rains**, even if this **did not compensate for the criticalities** of the current situation:

- Snowfall at an all-time low
- Water balance still in high deficit



Impacts on long-term hydropower production

Italian hydroelectricity production *for each 5-year period from 2015 to 2100 and for three climate scenarios calculated using the Moving Average with Shifting Horizon method* (MASH)

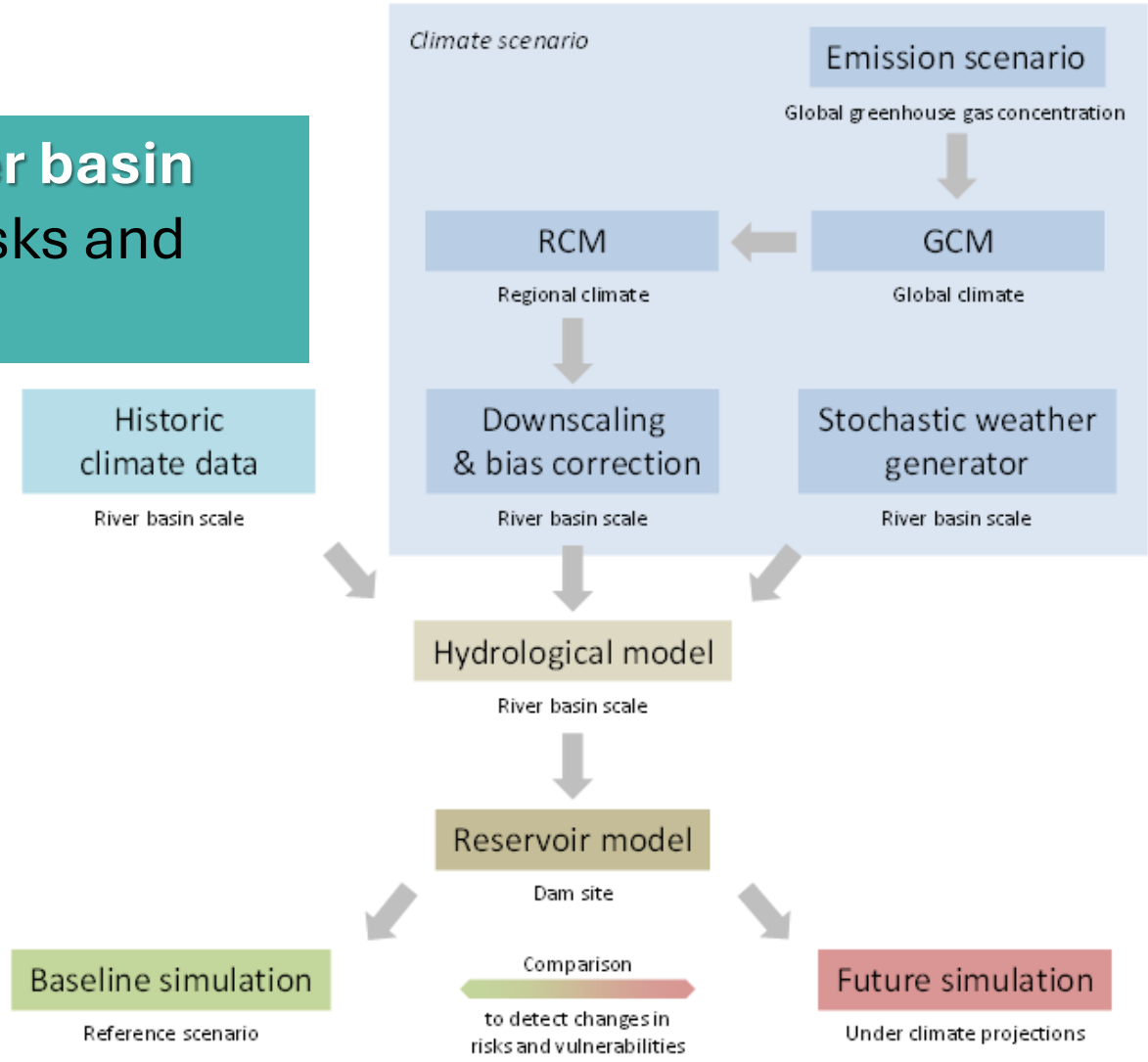


- Climate models provide similar qualitative trends for each 5-year period.
- **Emission scenarios** (Representative Concentration Pathways, RCP) are the **dominant factor on the long-term production change**.
- The temperature increase in the RCP8.5 scenario will cause a sharp **decrease in water availability** and an **increase in evapotranspiration**, with **reductions in producibility of up to 35% in the summer months**.

How to assess impacts on reservoir systems

Coupling of climate, hydrological and river basin models is essential to detect changes in risks and vulnerabilities over time

- Simulate climate projections based on the new **Shared Socio-economic Pathways** (SSPs) used in the **Coupled Model Intercomparison Project Phase 6** (CMIP6), considering different global **Effective Radiative Forcing** (ERF) in 2100.
- Apply **Artificial Intelligence techniques** in hydrology and water resources management.
- Adopt **advances repositories and a semantic approach** to store and process large volumes of data.
- Define asset **vulnerability curves** to quantify damage from extreme events and prioritize actions, if necessary.
- …



Source: ICOLD (bulletin under publication)

Impact of sedimentation on water storage capacity

13.753 Mm³
Total reservoir capacity in Italy

532
large dams

65 years
average age

Estimation of the current loss of storage capacity

-13%	**Authority restrictions on water storage**	-1.800 Mm³
-30%	**Volume of reservoir lost through siltation**	-4.000 Mm³

The **Climatic Rainfall Hydrogeological Modelling Experiment** (CRHyME) model computes the degree of sedimentation over the long term by referring to the extension of the catchment area:

- Extreme geo-hydrological instability phenomena will increase in intensity and frequency.
- Flood events clearly lead to the largest sedimentation increase.
- The solid production will increase in the Alps, where the hydrological cycle will change from a pluvio-glacial to pluvio-nival regime.

Turn climate change into opportunities

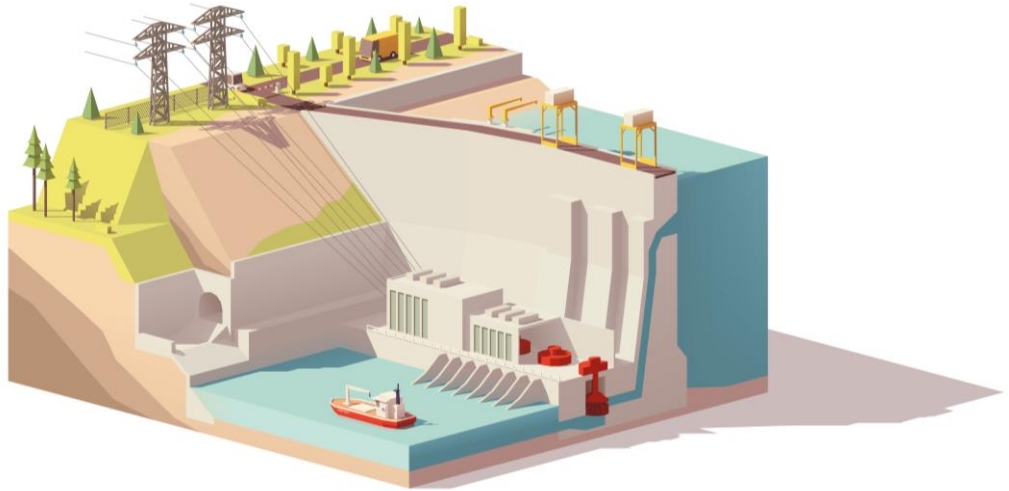
Understanding the complex inter-sectoral dynamics of **water, climate, energy and food nexus** is a cornerstone to streamline water-related policies to achieve the overarching goals of the European Green Deal, whose aim is to turn environmental and climate challenges into opportunities, making EU's economy sustainable (clean and circular) and still competitive.

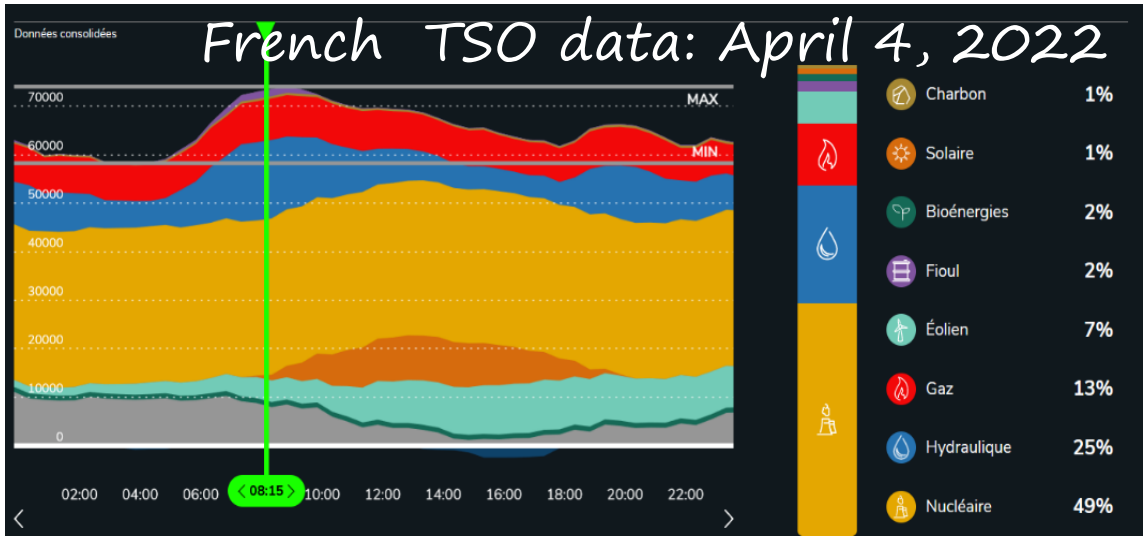
Effective **climate adaptation actions** must be undertaken urgently across all sectors and regions to avoid hindering efforts to achieve Sustainable Development Goals

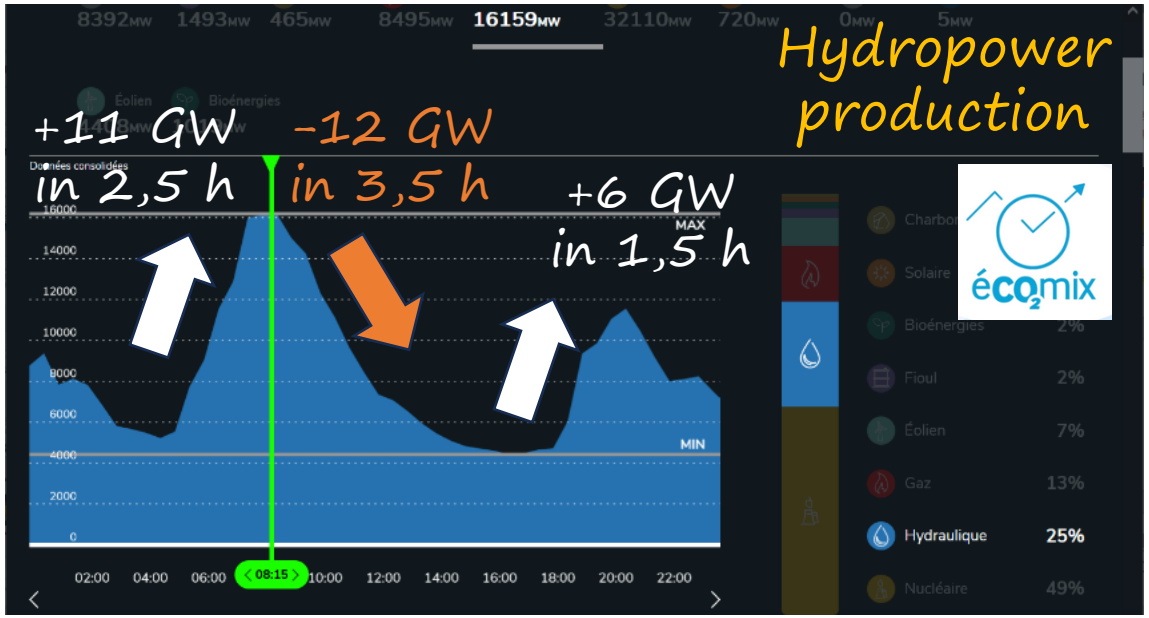
Balancing-services provided by hydropower

The exploitation of variable renewable resources has risen the **need for balancing-services** to stabilize the power network at each time horizon.

In recent years, this need has created the conditions for a **renewed interest in hydropower**, which provides **clean**, **flexible** energy and **storage capacity** to shift generation over time.



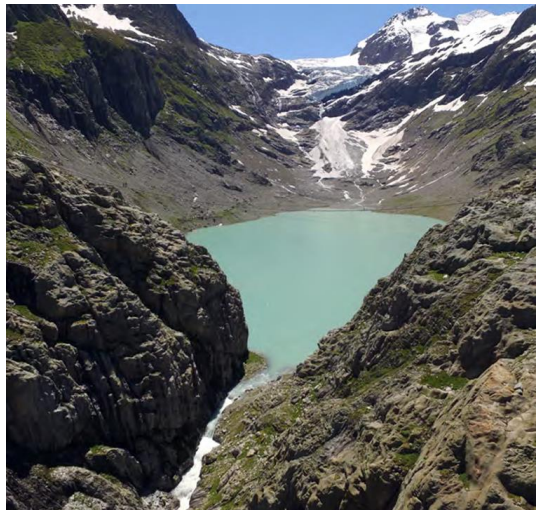


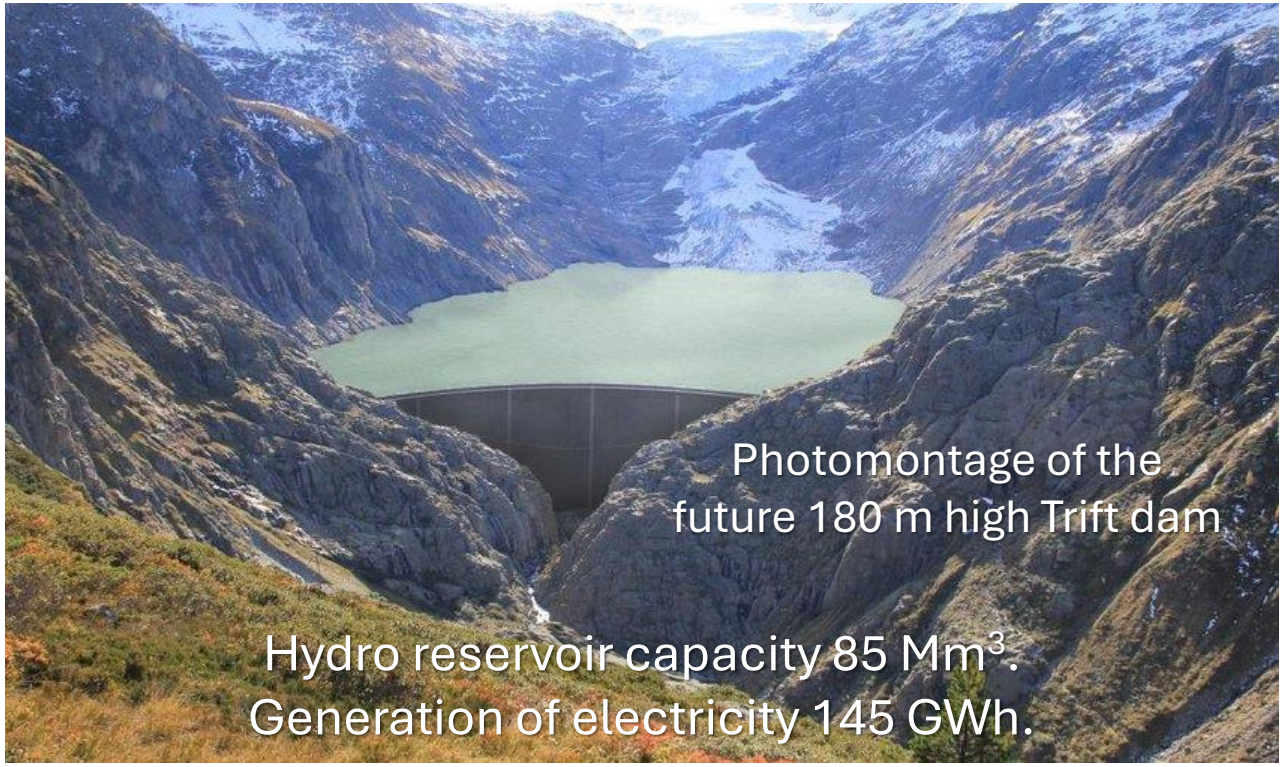


Reservoirs where glaciers once were?

Trift Glacier in the central Alps of the Bernese Oberland

In 1948, there was still glacial ice at 2,500 m asl.
In 2008, a lake had already formed at this site.
In 2014, the glacier ended clearly above the lake.
Glacial melting is reducing water reserves.





Retreating glaciers are releasing areas that could be used as possible sites for reservoirs, as natural lakes often already emerge here.

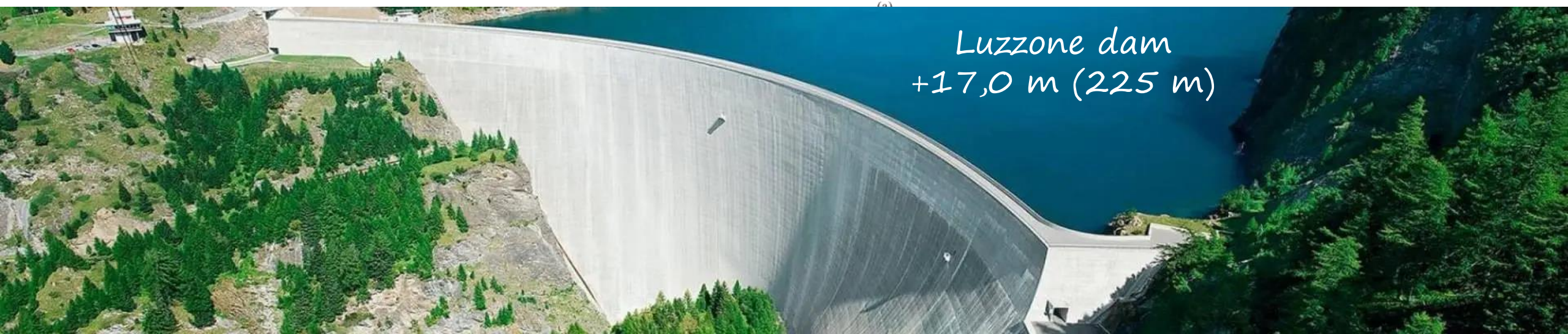
Glaciers transport large quantities of sediment that must be considered during the planning of new power plants.

More electricity thanks to the heightening of dams

In Switzerland, the heightening of 19 existing dams from 5% to 20% has been examined to contribute to the Swiss Energy Strategy 2050.

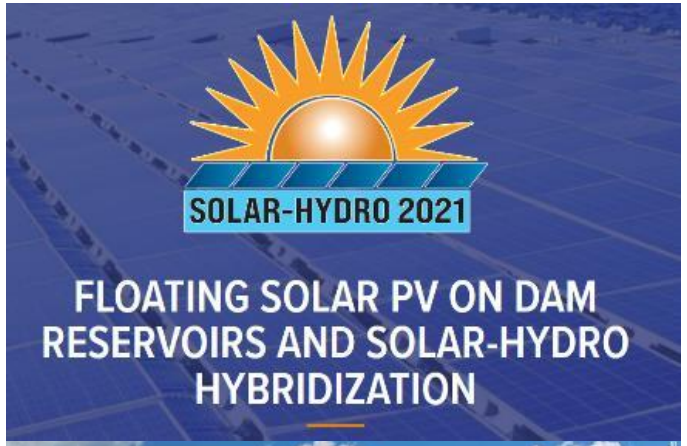
- An additional volume of 700 km^3 can be provided.
- A shift in production from summer months to the winter season is expected by about 1.7 to 2.8 TWh per year.

Some projects have already been realized in the past.



Hybridization with other technologies

Hydro & floating PV



Demonstrator in France at EDF Lazer reservoir

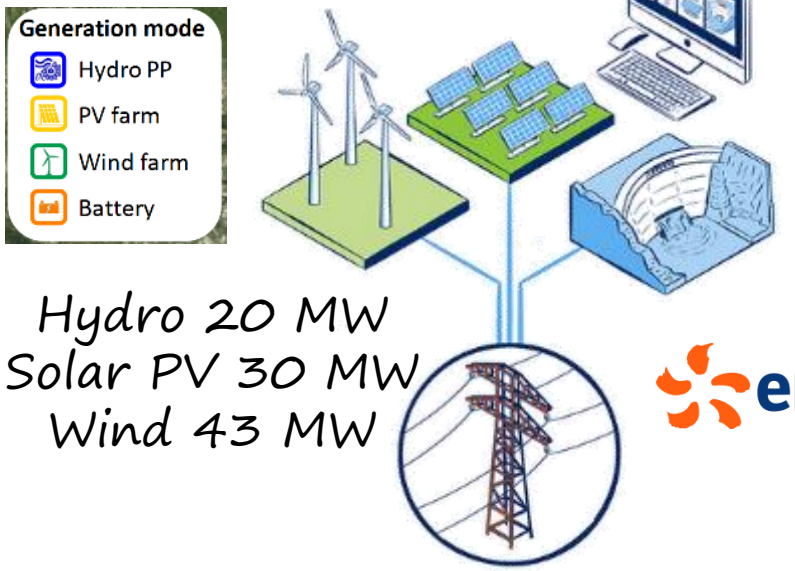
XFLEX HYDRO

Improve ancillary of primary frequency control

Variable speed reversible pump-turbine

Virtual Power Plants

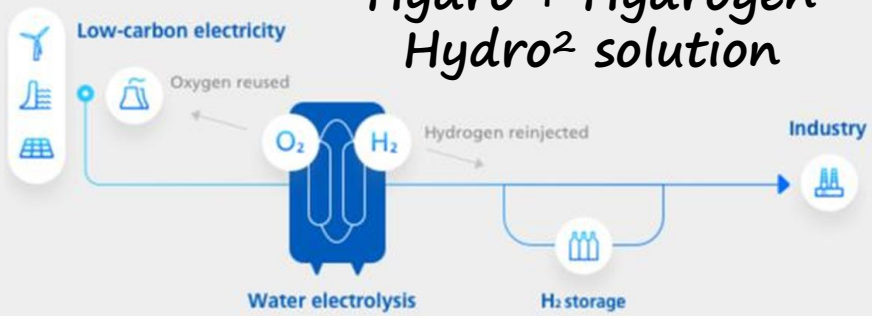
SO FLEX'hy



Hydro 20 MW
Solar PV 30 MW
Wind 43 MW

EDF

Hydro + Hydrogen Hydro² solution



Thank you for your attention

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